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DEVELOPMENT OF MULTI-COORDINATE VOCABULARY, PLASMA PHYSICS.

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DESCRIBED IS THE DEVELOPMENT OF A THESAURUS FOR THE FIELD OF PLASMA PHYSICS, SIMILAR TO THE ONE PREVIOUSLY DEVELOPED FOR CHEMICAL PHYSICS, FOR USE WITH COMPUTER-ORIENTED RETRIEVAL SYSTEMS. AN EXPERT IN THE FIELD OF PLASMA PHYSICS SELECTED TERMS IMPORTANT TO THE INFORMATION USER FROM THE PLASMA LITERATURE. THE HIERARCHY OF CLASSIFICATION UTILIZES FOUR MAIN CATEGORIES--(1) PROPERTIES, (2) PHENOMENA, (3) OBJECTS, AND (4) METHODS. THE OBJECTS AND METHODS CATEGORIES ARE HIERARCHICALLY ARRANGED. THE OBJECTS CATEGORY INCLUDES (1) PLASMAS AND MODELS OF PLASMAS, (2) ASTROPHYSICAL AND GEOPHYSICAL OBJECTS, (3) THERMONUCLEAR CONTAINMENT SCHEMES, AND (4) OTHER TECHNICAL APPLICATIONS AND EXPERIMENTAL DEVICES. THE METHODS CATEGORY HAS FIVE SUBDIVISIONS--(1) THEORETICAL--EQUATIONS, (2) THEORETICAL--SPECIAL SOLUTION TECHNIQUES, (3) EXPERIMENTAL--MEASUREMENTS, (4) EXPERIMENTAL--TECHNIQUES, AND (5) EXPERIMENTAL--DEVICES. THE VOCABULARY WAS SUBMITTED TO MEMBERS OF THE DIVISION OF PLASMA PHYSICS OF THE AMERICAN PHYSICAL SOCIETY FOR DISCUSSION, SUGGESTIONS, AND REVISIONS. THE VOCABULARY IS GIVEN IN APPENDIX A OF THE REPORT AND IS APPLIED TO EXAMPLES OF INDEXED JOURNAL ARTICLES IN APPENDIX B. (DH)

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DEVELOPMENT OF MULTI-COORDINATE VOCABULARY:

PLASMA PHYSICS

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DEVELOPMENT OF MULTI-COORDINATE VOCABULARY: PLASMA PHYSICS

Rita G. Lerner

The development of a thesaurus for the field of plasma physics is described. The thesaurus appears as Appendix A.

An empirical method of preparing a physics thesaurus has been described in an earlier report (ID 68-3, Development of a Multi-coordinate Vocabulary: Chemical Physics). It was decided to expand the multi-coordinate index to cover other areas of physics. It seemed appropriate to make the next area the field of plasma physics. We estimate that there is a total of about 1000 articles a year appearing in this field; this would make it feasible to index a considerable portion of the plasma physics literature for several years, thus enabling us to use plasma physics as a prototype of a physics information system. In addition to the AIP project, experimental systems in plasma physics were being developed by Physics Abstracts, (published by the Institution of Electrical Engineers, London), and the United Kingdom Atomic Energy Authority at their Culham Laboratory. A computer-oriented system could then be established using the indexing terms of Physics Abstracts, AIP, Culham, and Nuclear Science Abstracts in order to provide a series of products, such as current awareness journals and annotated bibliographies, which would provide a comparison of the different systems and help to establish the best means of reference retrieval.

The method used for chemical physics was applied to the development of a thesaurus for plasma physics. An expert in the field of plasma physics, Professor C. K. Chu of Columbia University, selected those terms which he regarded as important <u>to the user</u> from a body of plasma physics literature consisting of several volumes of The Physics of Fluids, The Physical Review, Nuclear Fusion Part C, and the Soviet Journal of Experimental and Theoretical Physics.

The same definition of physics as "the study of the properties of objects by methods" was used to break down the terms into lists as was used for chemical physics. As an experiment, however, it was then decided to separate "Phenomena" from "Properties", since a phenomenon may be said to resemble an object whose properties are determined. At present, the Phenomena Category is kept separate, but may be redefined as a subclass of either Properties or Objects. In this phenomenon category are terms such as "Shock Waves", "Instabilities" and "Turbulence".

It is possible to consider a mathematical model as an object in itself or as a theoretical method of calculating the properties of some object; in this case, we have arbitrarily assigned some models to the Objects category, and some to the category of Methods under the sub-heading of "Special Solution Techniques."

The Objects category is subdivided into four major headings:

1. Plasmas and Models of Plasmas
2. Astrophysical and Geophysical Objects
3. Thermonuclear Containment Schemes
4. Other Technical Applications and Experimental Devices

The Methods category is subdivided into five major sub-headings:

1. Theoretical: Equations
2. Theoretical: Special Solution Techniques
3. Experimental: Measurements
4. Experimental: Techniques
5. Experimental: Devices

Devices appears as a sub-class of both Objects and Methods; whether a paper is classified with the device as an object or a method depends on the nature of the paper. For example, in "Study of Anomalous Diffusion of a Cesium Plasma in a Q-machine," the Q-machine is a method, while in "Operating Characteristics of the Columbia University Q-machine," the Q-machine is the object. In the development of the chemical physics vocabulary, the decision was made to use personal names as little as possible in describing methods; in this way, it was hoped to avoid frequent revision of the vocabulary as new variations of methods are developed and subsequently named for their creators. However, it became apparent that this would not be possible in the area of theoretical methods, and we have identified various mathematical techniques with personal names.

The classification for a paper therefore consists of four categories, with one or more terms to be chosen from each category to describe the paper. Synonyms and quasi-synonyms appear on the same line. The preco-ordination of the terms on the category lists provides a multi-coordinate indexing of the journal article. The Properties & Phenomena lists are arranged hierarchically.

After the inital draft of the vocabulary was prepared, the chairman of the Division of Plasma Physics of the American Physical Society, Dr. Peter Sturrock, organized a committee of members of the Division to discuss the vocabulary and offer suggestions for additions and revisions. These suggestions were incorporated into the version of the plasma physics vocabulary which appears in Appendix A. Examples of the use of the vocabulary to index papers appear in Appendix B.

The authors gratefully acknowledge helpful discussions with the following members of the Division of Plasma Physics of the American Physical Society:

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Dr. Reece Roth	NASA (Lewis)
Dr. Martin Steele	RCA
Professor Thomas Stix	Princeton University
Professor Peter Sturrock	Stanford University

APPENDIX A

This vocabulary was prepared by C. K. Chu, Associate Professor of Engineering Science, Columbia University.

APPENDIX A

PLASMA PHYSICS LIST

PROPERTIES

Transport properties
- diffusion
- viscosity
- thermal conductivity
- electrical conductivity

Electrical properties
- conductivity
- dielectric tensor
- dispersion relation

Radiation
- spectrum
- emissivity
- absorbtivity
- refractivity

Excitation States
- model atoms

Ionization Potential

Adiabatic Invariants

Electron Velocity Distribution

Scattering Cross Section
- elastic collisions
- ionization
- excitation and de-excitation
- recombination
- Bremsstrahlung
- charge exchange
- thermonuclear reactions
- ion-atom/ion-molecule
- differential

PHENOMENA

Collisions
- electron-electron
- electron-ion
- atom-atom
- electron-atom
- ion-ion
- ion-atom/ion-molecule
- elastic and inelastic collisions

Collisional Processes
- ionization
- excitation
- recombination
- Bremsstrahlung
- charge exchange
- thermonuclear reactions
- de-excitation
- differential scattering
- recombination: 3-body, Thompson 3-body, dissociative, dielectronic, radiative
- coulomb

Turbulence and Fluctuations
- inertial regime
- dissipative regime
- electric field fluctuations
- magnetic field fluctuations
- density fluctuations
- energy/temperature fluctuations
- stochastic acceleration/heating

Instabilities
- flute or interchange
- hydromagnetic
- Rayleigh-Taylor
- Two-stream
- electromagnetic
- drift wave/universal
- resistive/finite resistivity
- micro instability
- ion-cyclotron
- mirror/diamagnetic

PHENOMENA

Plasma Waves and Oscillations
- electrostatic
- electromagnetic
- magnets hydrodynamic/hydromagnetic
- Alfven
- ion-cyclotron
- resonances
- damping, collisionless
- damping, collisional
- ion-acoustic

Shock Waves
- structure
- precursors
- magnetohydrodynamic
- ionization
- collisionless
- propagation shocks
- stability of shocks
- geomagnetic

Radiation
- absorption of radiation
- radiation through optically thick media
- radiation through optically then media
- electromagnetic
- scattering
- spectral-line
- Bremsstrahlung
- cyclotron
- Rayleigh-Jeans/black body
- Stark effect
- Faraday effect
- Zeeman effect
- radiation

Scattering
- wave-wave
- Thomson
- Raman
- in turbulent media

Equilibrium of Plasmas

Plasma-Solid Interactions
- thermionic emission
- cold emission
- Schottles Effect
- sheaths
- ambipolar region
- secondary emission
- contact potential
- Fermi level
- work functions
- plasma boundary layers

OBJECTS

Plasmas and Models of Plasmas:
- fully ionized plasma
- partially ionized plasma
- collisionless plasma
- radiating plasma
- single-fluid plasma
- multi-fluid plasma
- cold plasma
- non-equilibrium plasma
- relativistic plasma
- inhomogeneous plasma
- plasma column
- hydrogen plasma
- alkali metal plasma
- plasma with impurities
- noble gas plasmas (argon, helium, etc.)
- confined/bounded plasmas
- infinite/unbounded plasmas
- solid state plasma
- seeded plasma
- combustion/flame plasma
- stationary plasma
- flowing plasmas
- 2-termperature plasmas
- weakly ionized plasmas (Lorentzian)
- collision dominated plasmas

Astrophysical and Geophysical Objects
- stellar structure
- solar atmosphere
- solar corona
- solarwind/interplanetary gas
- interstellar gas
- intergalactic gas
- ionosphere
- magnetosphere/geomagnetic cabity
- radiation belts/Van Allen belts
- cosmic rays
- sunspots
- chromosphere
- flares
- radio bursts
- radio sources
- radio galaxies
- quasars
- supernova remnants

Thermonuclear Containment Schemes
- pinches, linear and toroidal
- mirror machines
- cusp geometry
- minimum B geometry/magnetic well
- toroidal systems/stellarator
- astron
- plasma injection systems
- thermonuclear heating schemes
- trapping of energetic particles

Other Technical Applications and Experimental Devices
- MHD generators
- MHD accelerators
- Plasma accelerators/plasma guns
- plasma jet
- shock tube, electromagnetic
- shock tube, coventional
- T-tube
- Q-machine
- Satellites
- electrostatic probes
- lasers
- arcs
- Penning discharge
- ion magnetron/PIG source
- ion engines
- gas discharge experiments
- thermionic converters
- arc jets
- discharge

METHODS

Theoretical: Equations

- Boltzmann's equation
- Vlasov equation/collisionless Boltzmann eq.
- Fokker-Planck equation
- Balescu-Lenard equation
- hierarchy equations/BBGKY equations
- Lindquist equations/ideal MHD equations
- Single fluid MHD equations, dissipative/ Navier-Stokes eq.
- CGL equations/Chew-Goldberger-Low equations/ guiding center fluid equations double-adiabatic theory
- single particle orbit theory/adiabatic theory
- Maxwell's equations
- Schrodinger equation
- Liouville equation
- Hamiltonian system
- rate equations
- multi-fluid equations

Theoretical: Special Solution Techniques

- Chapman-Enskog expansion/ Hilbert expansion
- moment method
- asymptotic methods/matched expansions
- Hilbert space theory
- variational techniques
- perturbation theory techniques
- numerical methods/Computer experiments
- computer solution
- dimensional analysis/similarity analysis
- non-linear theory
- Wiener-Hopf technique
- group theoretical methods
- classical mechanics
- spherical harmonic expansion
- one dimensional particle models
- two-dimensional particle models

Experimental: techniques

- laser applications
- interferometry
- Schlieren and shadow graph
- microwave applications
- probes spectroscopy
- solid state particle detectors (energy sensitive)
- electrostatic energy analyzers
- magnetic energy analyzers
- calorimetric
- foil stripping neutral detectors

Experimental: Measurement of

- conductivity
- plasma density
- plasma noise
- decay time
- current
- electric field
- electron density
- particle energy
- electron temperature
- ion temperature
- magnetic field
- resonant frequency
- radiation
- wave propagation
- nonadiabatic effects
- neutron production
- thermonuclear power production
- flow velocity
- gas temperature
- electron velocity distribution
- state populations
- thermal conductivity)transport prop
- thermal diffusion)
- viscosity

Experimental: techniques

- pinches, linear and toroidal
- mirror machines
- cusp geometry
- minimum B geometry/magnetic well
- toroidal systems/stellarator
- astron
- MHD generators
- MHD accelerators/ion engines
- plasma accelerators/plasma guns
- plasma jet
- shock tube, electromagnetic
- shock tube, conventional
- T-tube
- Q-machine/steady state machine
- satellites
- gas discharge experiments/gas discharge tubes.
- lasers
- arcs
- probes
- thermionic conversion

APPENDIX B

EXAMPLES OF INDEXED JOURNAL ARTICLES

Confinement of a Cesium Plasma in a Mirror Field

N. D'ANGELO AND S. v. GOELER*
Plasma Physics Laboratory, Princeton University, Princeton, New Jersey
(Received 9 December 1965)

Confinement of a thermally-ionized cesium plasma has been investigated in a magnetic mirror geometry. The mirror ratio R has been varied continuously between 1 and 5.7. The observed confinement of the plasma can be accounted for in terms of resistive diffusion and ion recombination at the end plates of the Q device. "Bohm" diffusion appears to be inoperative in the conditions of the experiment.

The Physics of Fluids 9, 1843 (1966) Experimental

Phenomena
Collisional Processes-recombination

Property
Diffusion

Object
Alkali metal plasma

Method
Mirror machine
Plasma density

Unstable Transverse Waves in a Plasma with Anisotropic Ion Distribution

CHING-SHENG WU
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California
(Received 13 January 1966; final manuscript received 4 May 1966)

The unstable transverse waves in an anisotropic multicomponent plasma are studied. Stability criteria are first established, and then it is shown that the anisotropic ion distribution may result in instabilities even if the electrons have isotropic distribution.

The Physics of Fluids 9, 1852 (1966) Theoretical

Phenomena
Plasma waves, electromagnetic
Instabilities, electromagnetic

Property
Dielectric tensor
Dispersion relation

Object
Multi-fluid plasma

Method
Vlasov equations

Effect of a Time-Varying Transverse Magnetic Field on the Equilibrium of a Toroidal Plasma

JOHN O. KESSLER* AND ROLF M. SINCLAIR
Plasma Physics Laboratory, Princeton, University, Princeton, New Jersey
(Received 1 June 1965; final manuscript received 10 June 1966)

Experiments are described in which a localized magnetic field $\mathbf{B}_T(t)$ could be suddenly applied transverse to the main plane of the C stellarator. Under optimum conditions the plasma temperatures and decay times were similar to those obtained by conventional means. The field $\mathbf{B}_T(t)$ was used to demonstrate that a sudden change in the plasma equilibrium conditions is directly correlated with sudden changes of the plasma impedance. An explanation of this phenomenon in terms of macroscopic drift motions of the plasma is suggested.

The Physics of Fluids 9, 1856 (1966) Experimental

Phenomena
Plasma equilibrium (toroidal geometry)

Object
Hydrogen plasma

Method
Stellarator
Plasma density
Decay time
Ion temperature
Electron temperature
Magnetic well

NSF
SE

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